THE CAR FERRY TRAFFIC OF LAKE ERIE.

BY W. FRANK M'CLURE.

Winter navigation on Lake Erie between the coal shipping ports of Ohio and Canadian harbors, 60 miles across, has long been a problem. For more than a decade, Lake Erie car ferries have attempted to run uninterruptedly the year round, but time and again in late winter are overtaken by ice conditions which result in their being frozen in for weeks, sometimes a mile or more from shore. Nevertheless the car ferry traffic of this notable inland body of water is a success and is increasing. A new ferry, with novel features for ice battling, of which great things are expected, has recently been put into service, and it is reported that another large ferry is to be built next year.

The navigation season for ore vessels on the lower lakes closes during the early part of December. After this time business at the docks is suspended except for the loading of ore from stock piles into railroad cars bound for the furnace districts, and the loading of coal, steel, and other freight to the car ferries. There is a constant demand for American coal on the Canadian side and, as to the supply, it is more plentiful in winter for these routes than in summer, when large numbers of vessels are waiting for cargoes for the upper lakes.

One of the car ferry routes of Lake Erie extends from the port of Conneaut, Ohio, to Port Dover, Canada. Other Canadian ports which are reached from Conneaut are Port Stanley and Rondeau. The latest route on Lake Erie is one which has been inaugurated during the past year between Ashtabula, the world's greatest ore receiving port, and Port Burwell, in the Dominion. Any of these routes compares favorably in length with the notable ones of Lake Baikal, which connect with the Trans-Siberian railway.

The first two ferries introduced on Lake Erie were each 300 feet long, 54 feet beam, 60 feet high from keel to deck, and equipped as 3,500-horse-power ice crushers. The number of cars which could be placed aboard was from 26 to 30, depending on the size of the cars. The ice crusher, located at the bow and shaped something like a spoon, climbs up onto the ice in its path and crushes it down.

In 1904, another type of ferry—the "Marquette & Bessemer No. 1"—was placed on a coal route between Conneaut and Rondeau. This boat is not a car ferry in the strict sense of the word, since, while the cars are run aboard *via* two tracks, they are not carried across the lake but discharge their contents from hopper bottoms into a continuous hatch over which the tracks are suspended. Ten cars at one time can be unloaded in this manner. The capacity of the hold is 2,500 tons. At the Canadian terminal four grapple unloaders remove the cargo in eight hours. The time of unloading, of course, is much longer than that of a ferry which carries the loaded cars, but the load carried is several times as great and the time of loading is but little more than that of the regular car ferries. The length of this vessel is 255 feet, depth 22 feet, beam 43 feet.

The new car ferry "Ashtabula," for which this is the first winter, is notable especially for her water bottom, which is so controlled that she can free herself from the ice in several different ways, dependent upon the kinds of ice with which she has to battle, or other conditions. There are eight transverse bulkheads, six of which run to the car or main deck and two to the lower deck. The water in the compartments is controlled by ballast pumps. Simultaneously one pump may be pumping the water out of one compartment and another pumping into another compartment. By filling the tanks aft and pumping out the ones forward, the ferry's bow is made to climb up on to a field of ice and crush it down in its path. To plow directly into a field of ice, when traveling light, the vessel is lowered to the desired depth by filling all the water compartments. Again, in freeing herself from ice, it may be deemed best to list the ferry to one side. This is accomplished by filling the tanks on one side of the ferry and pumping out those on the other.

This ferry is 50 feet longer than the ones on the Conneaut-Port Dover line heretofore referred to, and has a 56-foot beam. Her keel is 330 feet, her depth 20 feet. She is propelled by twin screws, driven by two triple-expansion engines with cylinders 19½, 31, and 52 inches diameter by 36-inch stroke, supplied with steam from four Scotch boilers.

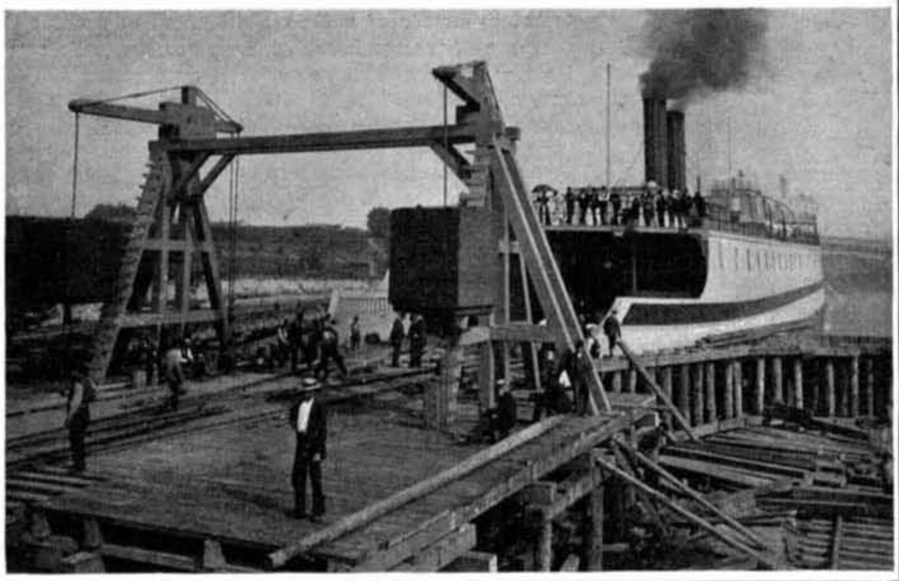
On board the car ferry "Ashtabula" there are four tracks. These tracks will accommodate thirty 50-ton cars coupled together and then fastened to bumper posts. New cars have been built especially for this ferry traffic. They are each 38 feet long.

In a cabin amidships are the galley and the eating quarters of the ferry. The dining room for officers and guests is elaborately furnished. There are also baths, lavatories, and all modern conveniences. Even the quarters of the deck hands are equipped for comfort. The vessel is lighted by electricity and, when in port, is connected with the telephone service. She was built at the yards of the Great Lakes Engineering Company at Detroit.

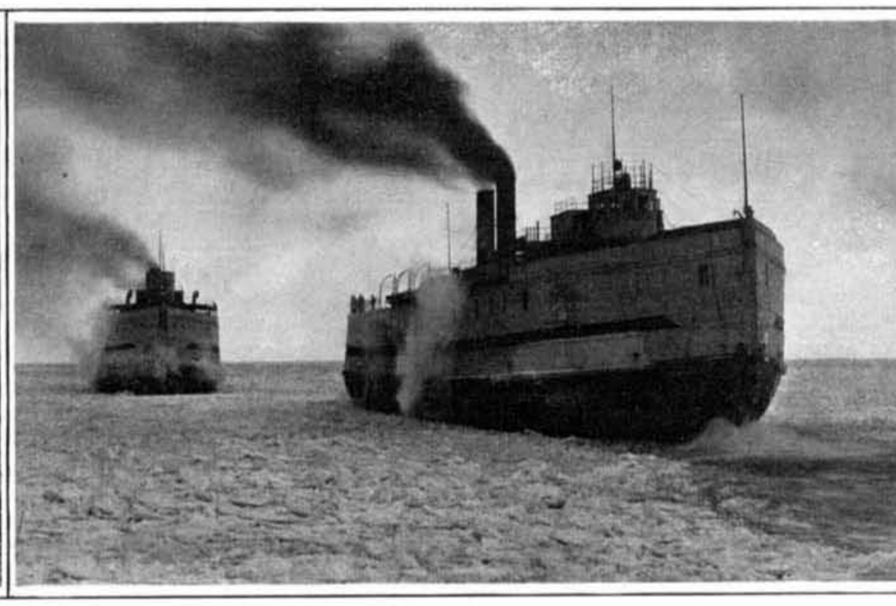
The ferry can make two trips a day between Ashtabula and Port Burwell. Her actual running time for the round trip on her official test was nine hours and twenty-five minutes. Going to Port Burwell with a full load of thirty cars of coal, and with the lake quite rough, she made a little more than 15 miles an hour and returning averaged 15¼ miles per hour.

The method of loading and unloading a car ferry calls for an apron which can be raised and lowered, and which is equipped with tracks which will connect the tracks of the docks with those on board the ferry. This apron hangs from powerful balance arms, from the opposite ends of which are counter-weights aggregating 40 tons. This lift is controlled by electric machinery. With the touch of a lever, the outer end of the apron can be raised or lowered to the level of the vessel's dock, the inner end working on rockers. The apron at the Ashtabula car ferry dock weighs 75 tons and is 30 x 52 feet in size. There are usually four tracks on the dock, four on the ferry, and two on the apron. The cars go to and from their respective tracks by switching. Two of the tracks in the car ferry yards are kept for empty cars and two for loaded cars. The switching of loaded cars aboard and empty cars to shore may progress at the same time. At the Canadian terminals, when switched to the docks, the cars are picked up by the Canadian railways and distributed to distant destinations for unloading.

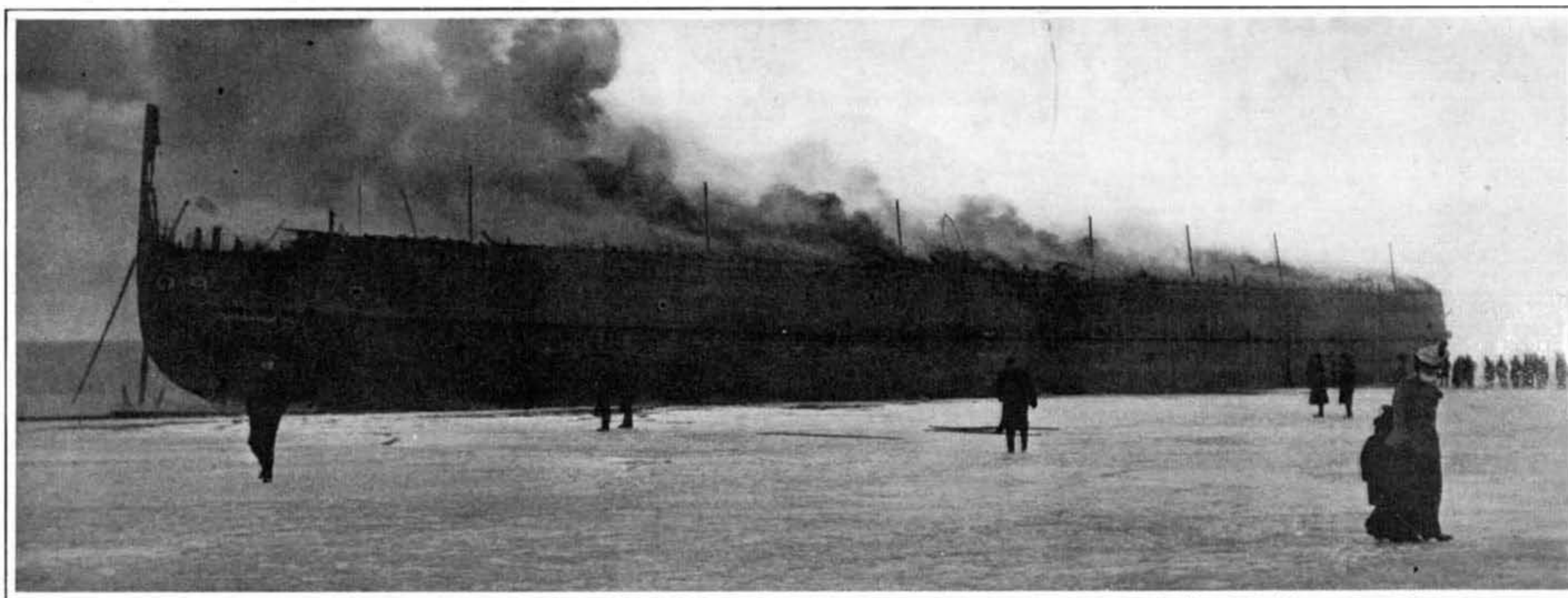
Lake Erie car ferries in starting out upon a one-day trip, in January and February especially, take with them a stock of provisions sufficient for at least three weeks. This is to provide for an emergency in case the ferry is frozen in on the route. When frozen in, members of the crews often walk to and from the mainland over the fields of ice. It was while thus stuck in the ice that the destructive fire shown in the accompanying photograph took place off Conneaut. This was some two years ago. The ferry burned was



The Apron of a Car Ferry Dock, Showing Counterweights Used in Its Operation.



Car Ferries Crossing Lake Erie Through Fields of Ice.



A Burning Car Ferry Caught in the Ice Off Conneaut Harbor.

THE CAR FERRY TRAFFIC OF LAKE ERIE.

"Shenango No. 1," which ran between Conneaut and Canadian ports.

The wind has a great deal to do with the ice conditions, often piling the ice up mountains high in the ferries' path. In such cases, if an opening can be found in the windrows, the ferry may break through. Otherwise, dynamiting is sometimes done with good effect.

THE BATTLESHIP OF THE FUTURE.—II.

BY FORREST E. CARDULLO.

(*Continued from page 133.*)

In the case of large guns, the most effective caliber of weapon is the minimum caliber which will give the requisite penetration at probable battle ranges. The greater the weight of a gun, the less the number of hits which it will score in a given time. The greater the weight of a gun, the less the number of them which can be carried on a given displacement. Two shells of 1,000 pounds weight each will have more destructive effect than will one shell of 2,000 pounds weight, provided that they have sufficient penetrative power. From these several considerations, it becomes apparent that a large number of guns of sufficient caliber are much to be preferred to a smaller number of larger guns.

There is reason to believe, however, that the weights of projectiles of given calibers will be increased. If a number of projectiles of different weights be fired from the same gun with the same powder charge, all will have the same muzzle energy. The lighter ones will have the higher initial velocity, the greater penetrating power, and will experience the greater air resistance. On account of this resistance, the velocity, the striking energy, and the penetrating power of the lighter projectiles will fall off much more rapidly than is the case with the heavier projectiles, so that at the longer ranges, the advantage lies entirely with the latter. Let us take for example a 12-inch gun firing 800, 1,000, 1,200, and 1,400-pound projectiles, as shown in Table I. At the muzzle, and at 3,000 yards range,

TABLE I.

Length of gun, 50 calibers. Powder pressure, 21 tons per sq. inch.

Range, yds.			Zero.		3,000		6,000		9,000		12,000	
C.	G.	S.	V.	P.	V.	P.	V.	P.	V.	P.	V.	P.
12	65	800	3600	33.6	3030	25.8	2520	20 0	2060	14.6	1670	11.0
12	65	1000	3220	31.6	2790	25.2	2390	21.0	2030	15.2	1720	12.6
12	65	1200	2940	30.0	2600	25.0	2280	21.0	1990	16.7	1730	13.8
12	65	1400	2720	29.0	2440	24.5	2180	21.0	1940	17.4	1720	14.5

TABLE II.

Length of gun, 60 calibers. Powder pressure, 17 tons per sq. inch.

8	23	300	3160	19.5	2540	14.4	2010	10.4	1560	77.2	1222	5.3
10	45	580	3160	25 5	2670	20.0	2230	15.0	1840	11.5	1510	9.0
12	78	1000	3160	30.5	2730	24.6	2340	19.0	1990	15.6	1680	12.0
14	124	1600	3160	35.6	2790	29.5	2460	24.5	2150	19 0	1870	16.3
16	185	2400	3160	41.0	2840	35.6	2540	26.6	2260	24.8	2010	20.8

Length of gun, 50 calibers. Powder pressure, 27 tons per sq. inch.

8	23	350	3300	24 0	2760	18.4	2260	13.6	1830	10.0	1480	7.2
10	45	700	3300	30.0	2860	24.2	2460	19.3	2100	15 2	1780	11.9
12	78	1200	3300	36.0	2940	30 0	2590	25.2	2280	20.4	1990	17.0
14	124	1900	3300	42.0	2980	36.0	2680	30.7	2400	26.0	2140	22.0

In these tables C represents the caliber of the gun in inches, G the weight of the gun in tons, S the weight of the shot in pounds, and V and P the velocity in foot seconds, and the penetration of Krupp armor in inches respectively at the range given.

the lighter projectiles have the higher velocities, and the greater penetrations. At a little less than 6,000 yards range, all the projectiles have practically the same penetration, but the lighter ones are preferable, since they give the flatter trajectory, and will also score more hits for a given weight of ammunition carried. At 9,000 and at 12,000 yards range, it may be seen that the 1,000-pound or the 1,200-pound projectile is preferable, the greater penetration of the latter being offset by the flatter trajectory of the former.

A comparison for all the ranges shows that the 1,200-pound shot gives the best average results, and is the one that should probably be adopted for this particular caliber and muzzle energy. For a greater muzzle energy, both the weight of the shot and the muzzle velocity should be increased, if we are to secure the most effective service from the gun. It may be stated as a general rule that the weight of projectile should be so adjusted to the caliber and power of the gun that the remaining velocity at the longest probable battle range shall be a maximum. This principle will necessitate an increase of from 20 per cent to 40 per cent in the weights of projectiles of given calibers.

Table II. gives the ballistics of two series of guns such as we may expect to see on the battleship of the future. An inspection of this table develops the fact that a 14-inch gun is probably as large as will ever be mounted on shipboard. The 16-inch gun weighs 50 per cent more than the 14-inch gun. Twelve 14-inch guns would be more effective than eight 16-inch guns, since they would fire twice as many aimed shots per minute, each of which is practically as effective as one from the larger gun. Both shells will penetrate any armor likely to be afloat for some time to come, at 9,000 yards range. The 16-inch shell has the advantage when employed against very heavy armor at more than 9,000 yards range, but this is not sufficient to counterbalance the advantages of the 14-inch shell at more practical ranges. Whether or not the 14-inch gun shall establish itself as the standard primary weapon is not clear from the table. The use of vanadium, or possibly some as yet undiscovered element, in the manufacture of armor may confer upon it such resistant qualities as to make the adoption of a 14-inch gun advisable, or changes in the propelling machinery may make the adoption of much thicker armor possible, but if neither of these possible events comes to pass, it is probable that the 12-inch gun will remain the most powerful naval weapon.

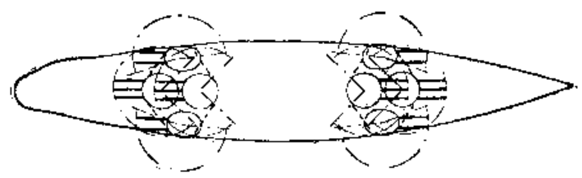


Fig. 7.—Twenty 12-Inch Gun Battleship. Two Groups, Each Containing Two 3-Gun and Two 2-Gun Turrets.

The proportion of weight which the modern designer devotes to armor is about 25 per cent. On the battleship "Connecticut" this gives us the equivalent of 12-inch armor over the vital parts of the ship. If the proportion of weight and distribution of armor remains the same, the thickness of the armor will vary as the cube root of the displacement. We should therefore expect a 20,000-ton ship to have 13 inches of armor, a 25,000-ton ship 14 inches of armor, and a 30,000-ton ship 14¾ inches of armor. None of this would be safe against guns of 10-inch caliber or over, at 6,000 yards, and the tendency will be to thicken it when possible. This may be done either by increasing the proportion of weight devoted to armor, or by reducing the area of the thin armor covering the non-vital upper works. The last method is far the best. If we increase the proportion of weight devoted to armor, it must be done at the expense of gun power. Any armor that can be made can be penetrated at some range, and our heavily armored ship may be attacked by a ship of thinner armor and superior gun power, and destroyed at short range where its superior armor is useless. At the same time, armor is necessary, for if a ship be unarmored, it would be quickly destroyed at long range by an armored vessel, while its own guns were powerless to inflict damage. There is a golden mean in the matter of the thickness and extent of armor carried, which will give the most powerful ship for the given displacement, and it will probably be found somewhere about as indicated in Table III.

TABLE III.

Displacement, Tons.	Armor Thickness, Inches.	Speed, Knots.	Displacement, Tons.	Armor Thickness, Inches.	Speed, Knots.
12,000	12.7	18.0	30,000	17 2	20.0
16,000	14.0	18.6	35,000	18.2	20.4
20,000	15.1	19.1	40,000	19.0	20.8
25,000	16.3	19.6			

In arranging the distribution of armor, the principle to be observed is to protect all of those parts of the ship whose integrity is essential to her fighting power, by armor of the greatest practicable thickness, giving all these parts substantially equal protection. The center of the ship constitutes a steel-walled fortress within which are assembled the boilers, engines, magazines, and other vital machinery and stores. In Fig. 8 are shown the midship and longitudinal sections of the ship shown in plan in Fig. 7. It will be seen that the walls of vertical armor constituting this fortress are about 12 inches thick above the water line, and taper to perhaps 9 inches thick at the lower edge, some six or eight feet below this. Meeting this lower edge is a sloping deck from 2½ inches to 4 inches thick, which becomes horizontal when it has risen to the same vertical height as the top of the armor belt. The end walls of the fortress, which are known as the armored bulkheads, are of about the same thickness as the side walls, but are protected by the armored deck, instead of protecting it. Thus any shot entering this central fortress must first penetrate two thicknesses of steel, one or both of which it must strike obliquely. If the projectile be a shell, the first thickness of armor will explode it, and the second thickness will effectually prevent the pieces from entering any vital spaces. The only projectile which can penetrate will be the comparatively harmless solid shot.

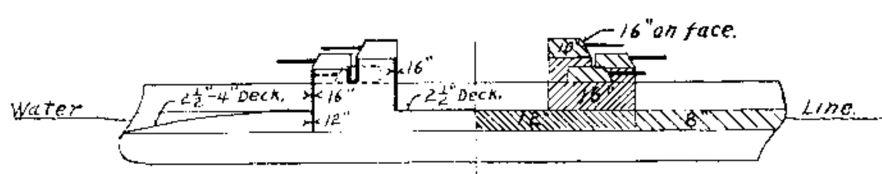


Fig. 8.—Longitudinal Section Showing Disposition of Armor.

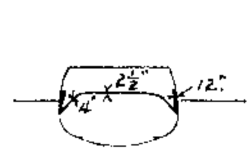


Fig. 8a.—Midship Section Showing Relation of Protective Deck to Belt Armor.

THE BATTLESHIP OF THE FUTURE.—II.

From the armored roof of this fortress rise the barbettes or citadels which form the supports for the gun turrets. The thickness of the armor inclosing these supports, and the ammunition hoists and gun mountings contained in them, will be about 16 inches in the case of the ship we are considering. The armor on the faces of the turrets will be of about the same thickness, while the sides and backs, being in general turned away from the enemy, will be thinner.

The entire water line of the vessel should be protected by armor of sufficient thickness to prevent the entrance of "common shell," a type of projectile carrying a very heavy and destructive bursting charge. This belt will have to be 8 inches thick if it is to oppose 14-inch guns, since common shell will pierce half its caliber of armor. There are a few other parts of the ship which it may be advisable to protect from shell fire, but in general the same principle holds in the case of armor as with guns, namely, that all armor should have the same resistance to penetration, just as all the guns should have the same penetrating power.

Besides the rifled gun, the only practical weapon of offense known to naval warfare is the torpedo. If two fleets of equal cost engage each other, the fleet of smaller and more numerous vessels will have the advantage in torpedo warfare. It will, however, be at a disadvantage with respect to gun power, armor, speed, and coal endurance. Since the vast majority of naval battles are decided by gun fire, the advantage will in general lie with the larger ships, but the possibilities of torpedo warfare will always act to prevent a further increase in the size of ships, if there is any doubt that the increase in size will confer a more than proportionate increase in power and efficiency. It is entirely possible that sufficient improvement may be made in the design and operation of torpedoes to throw a very decided advantage on the side of the smaller and more numerous ships, in which case the tonnages of the present may be adhered to for the future, or even reduced. This is a matter which can only be decided by pushing to the limit the development of torpedoes.

To have such an effect on the size of our future battleships, a torpedo must be designed with an effective range nearly equal to the effective range of the guns carried. It is not sufficient that the torpedo should run merely the distance indicated, but its speed and accuracy must be such that there shall be a reasonable percentage of hits, and its power must be sufficient to inflict a great deal of damage. Mechanically, it is possible to construct a torpedo of sufficient range and power, but the chances of a hit are very slim, unless used against a disabled ship, or a large fleet maneuvering in certain formations. We may construct a torpedo two feet in diameter and twenty feet long to carry 500 pounds of high explosive at a speed of 50 knots or more, and to execute any assigned course over a given area. If the course of a distant hostile fleet could be predicted for say eight or ten minutes ahead, it would be possible to have fifty or one hundred of these terrible engines of destruction continually circling in the waters over which the fleet would pass. Such a development of torpedo warfare would certainly affect naval tactics, and probably, battleship design.

No protection that we know of at the present time will avail against the torpedo if the size and cost of that weapon be sufficiently increased. To repel the attacks of torpedo boats, a battleship must be armed with a battery of from twelve to twenty guns of small caliber. It is evident that the effective range of these guns must exceed the effective range of the torpedo, that the caliber of the shell must be sufficient to destroy the torpedo boat before it has launched its bolt, and that the rate of fire must be very high. To obtain the requisite range and stopping power, a 5-inch gun is necessary, and to obtain a sufficient rapidity of fire to make such a defense effective against a simultaneous attack by several boats, the operation of the gun should